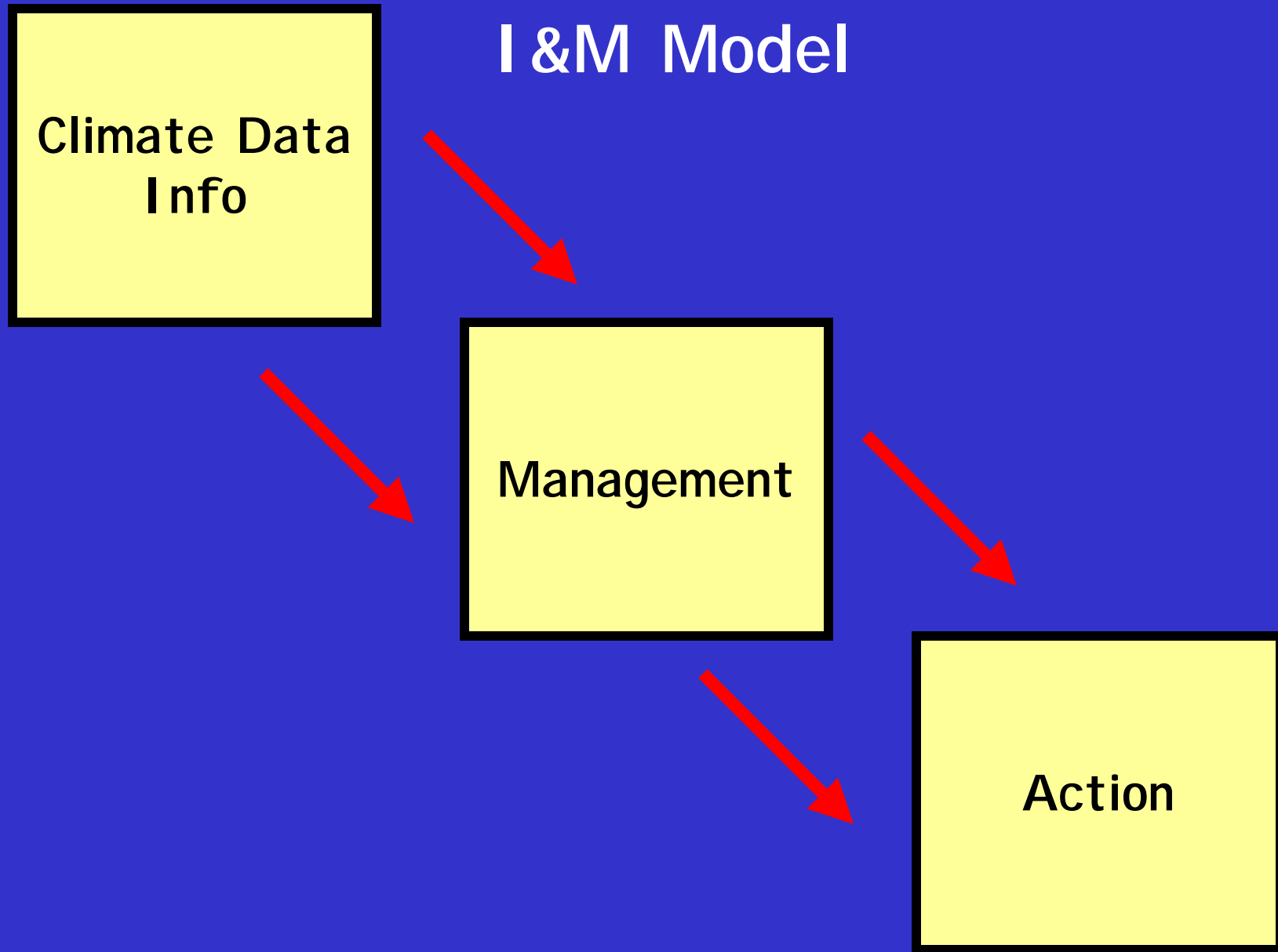


The National Park Service I & M Model



Climate Data
Info



Lack of data
Dissemination
Accessibility
QA/QC

Management

Understanding
of climate-ecosystem
interactions



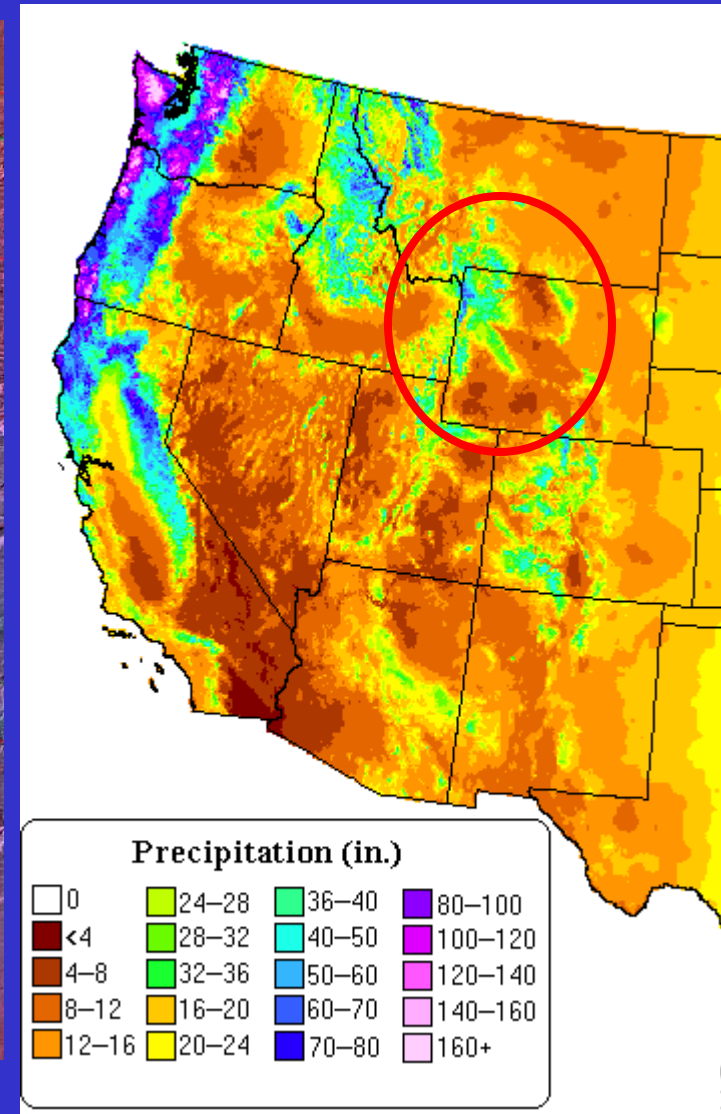
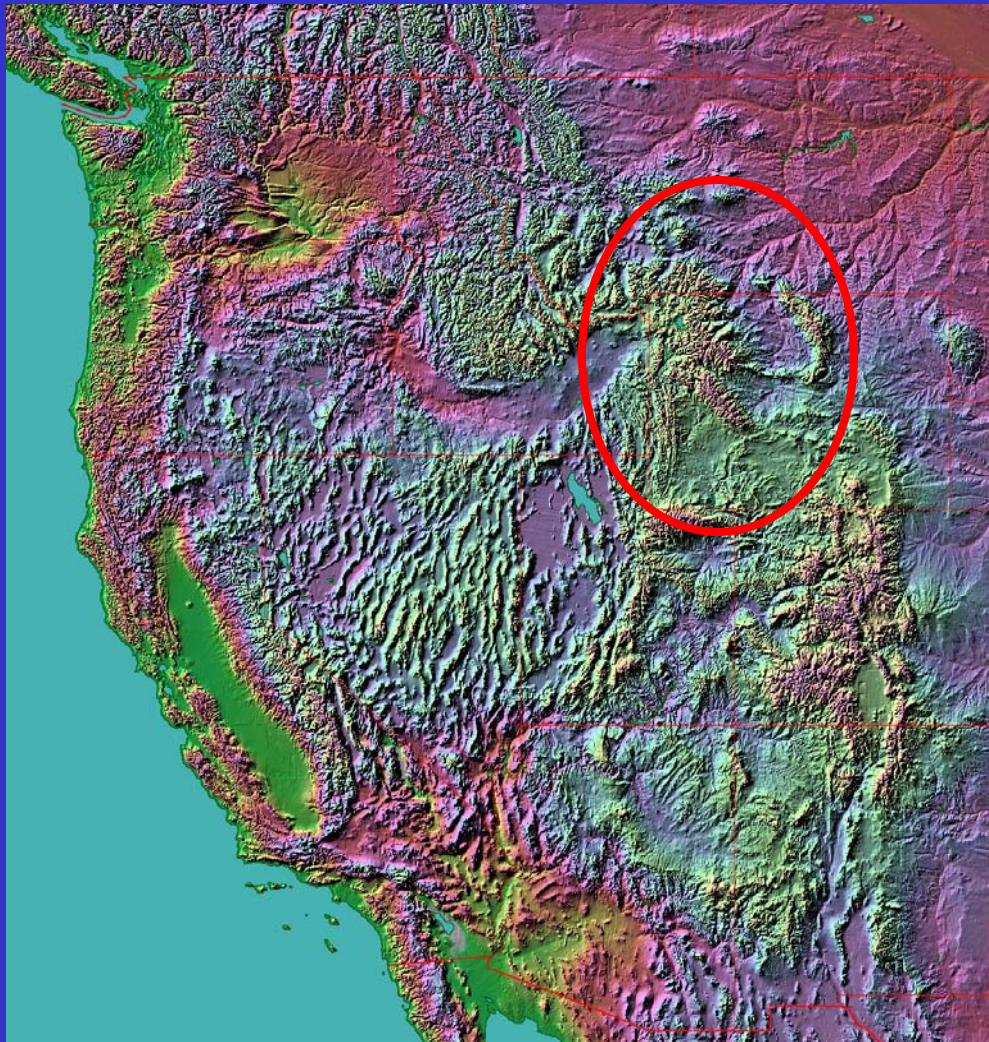
Action

Climate Variability and Climate Change in Western Natural Areas

Implications for Management
Challenges for Monitoring and
Mitigation

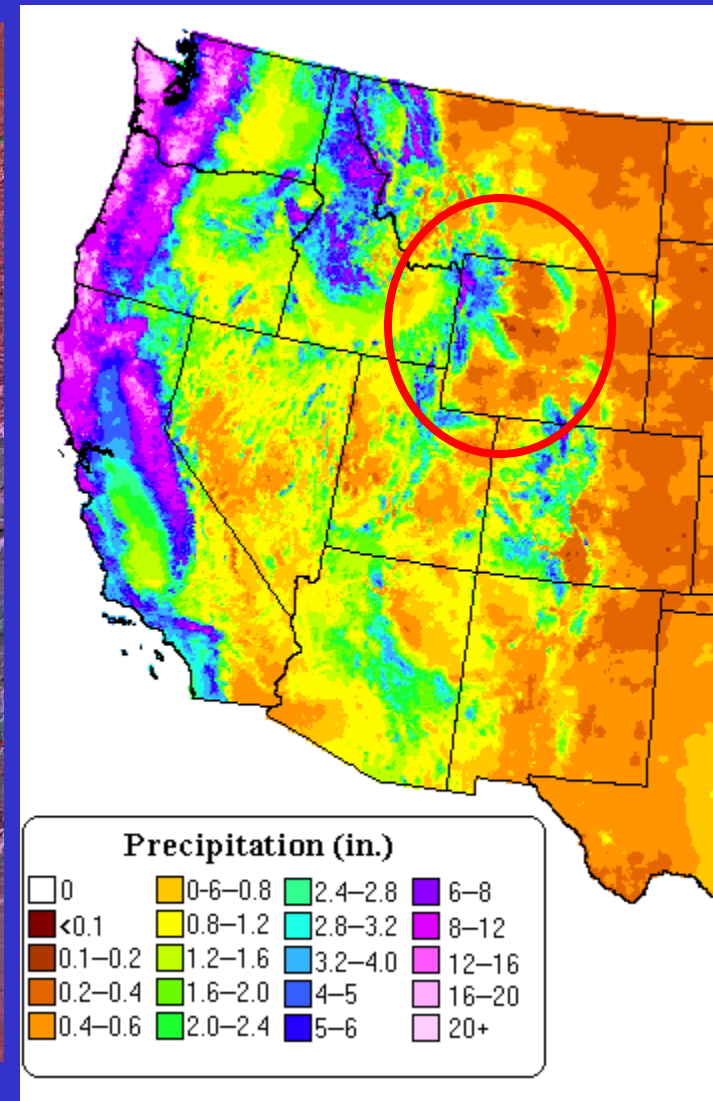
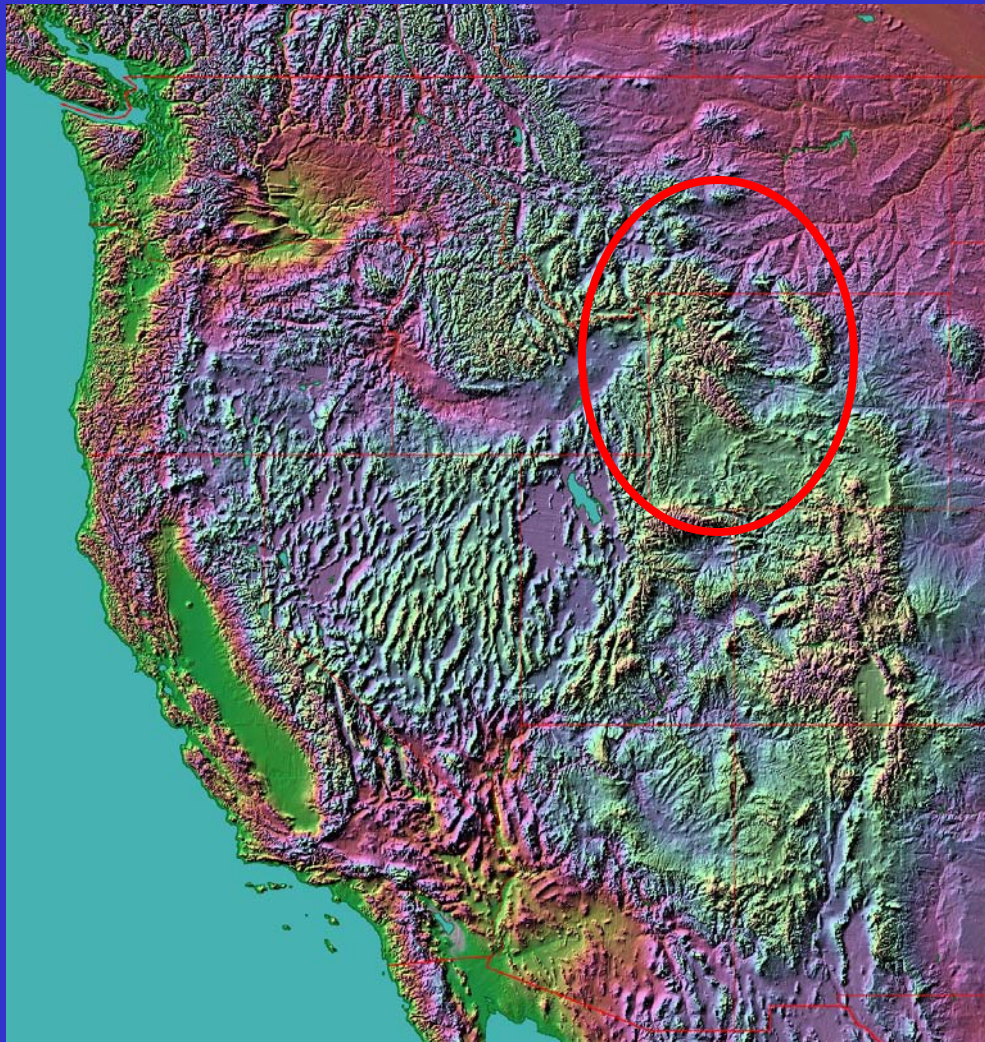
Stephen Gray, USGS

Western US Topography



Annual Precipitation

Western US Topography

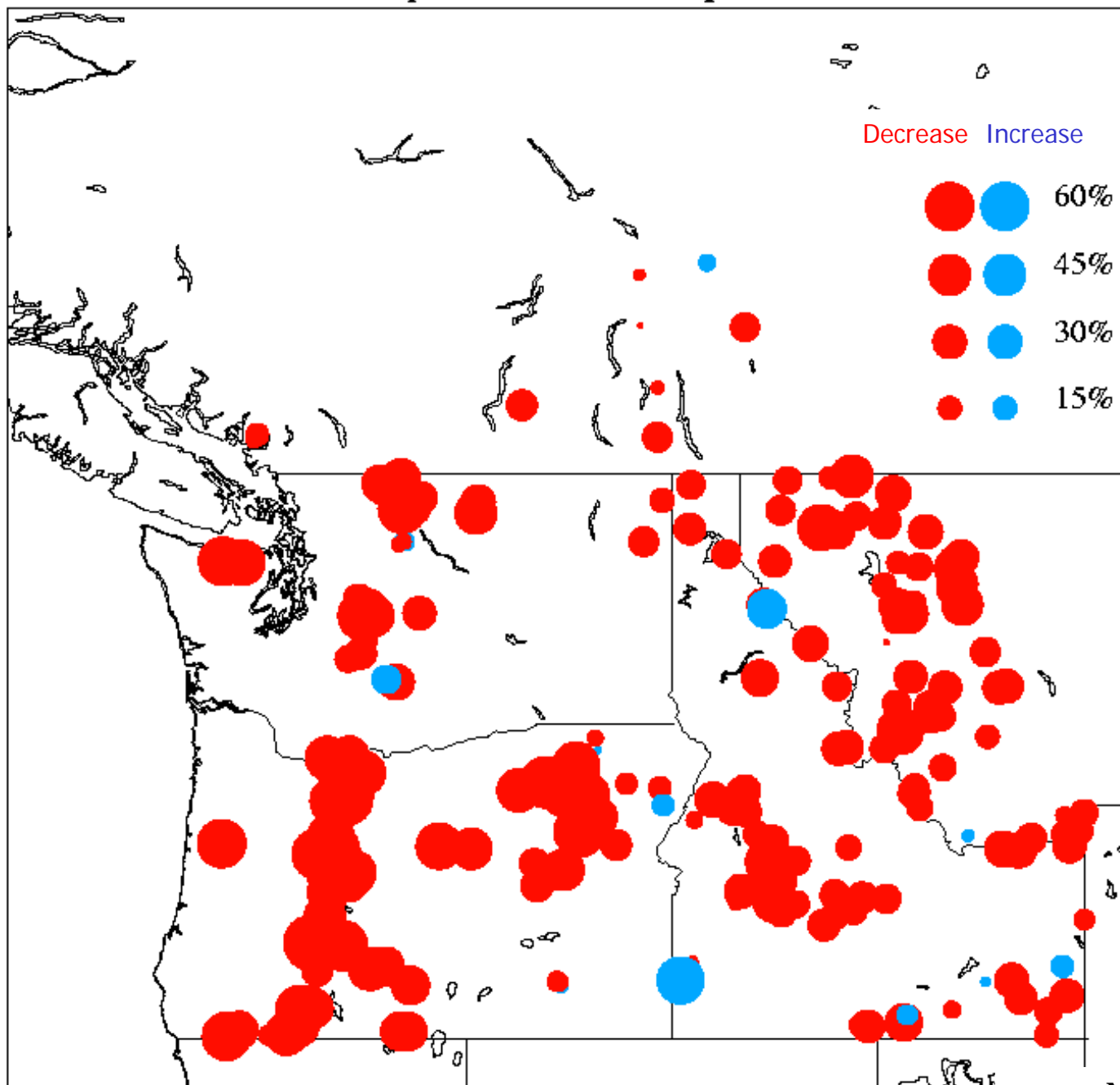


January Precipitation

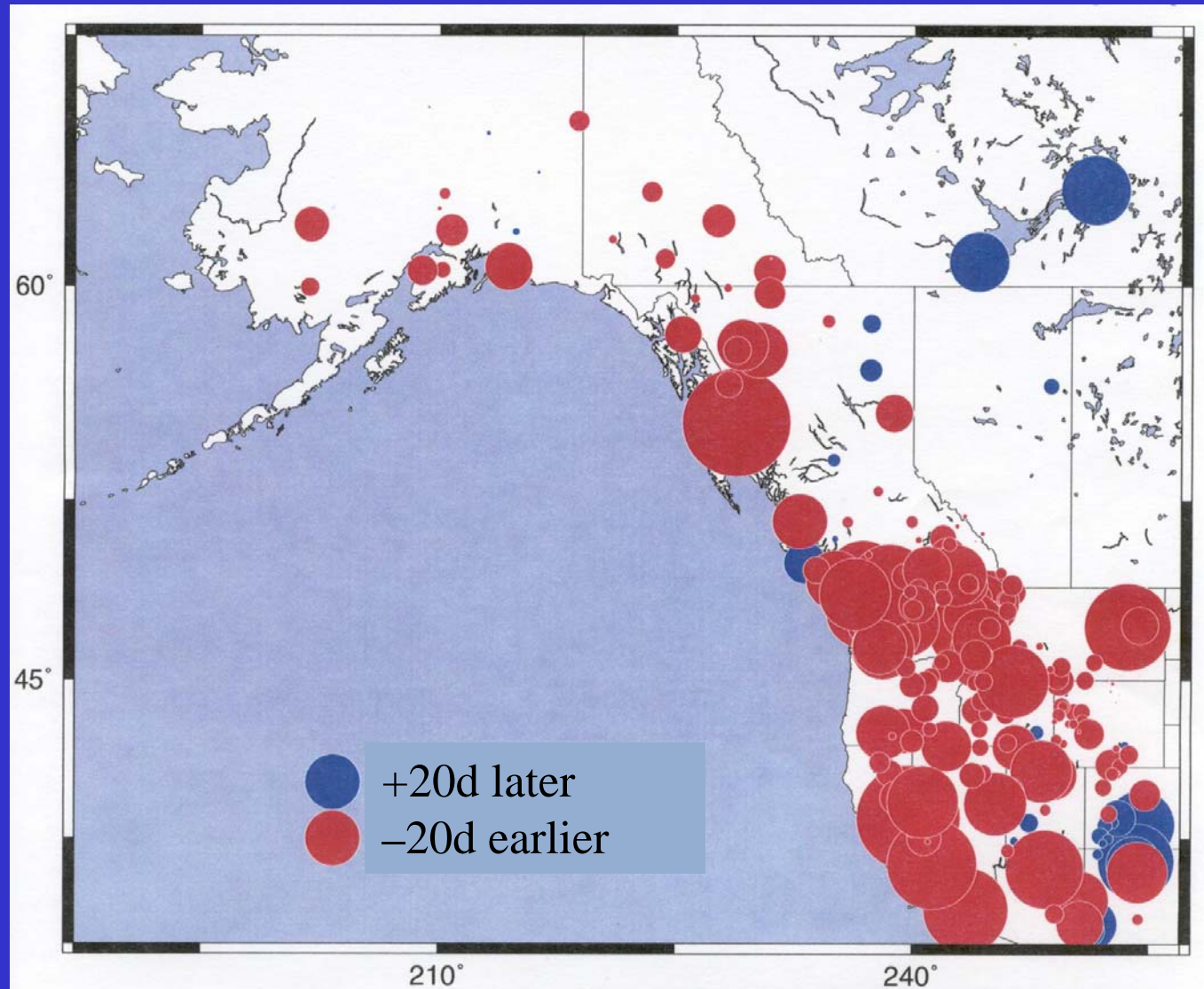
Importance of Snow in Western Ecosystems

- Low elevations
 - *Streamflow/runoff*
 - *Aquatic/riparian systems*
 - *Surface water in arid environments*
- Mid-elevations
 - *Soil moisture recharge*
 - *Controls on plant community composition*
- High elevations
 - *High productivity*
 - *Support many systems of interest (e.g. whitebark pine)*

Relative trend in Apr 1 snow water equivalent, 1950-2000

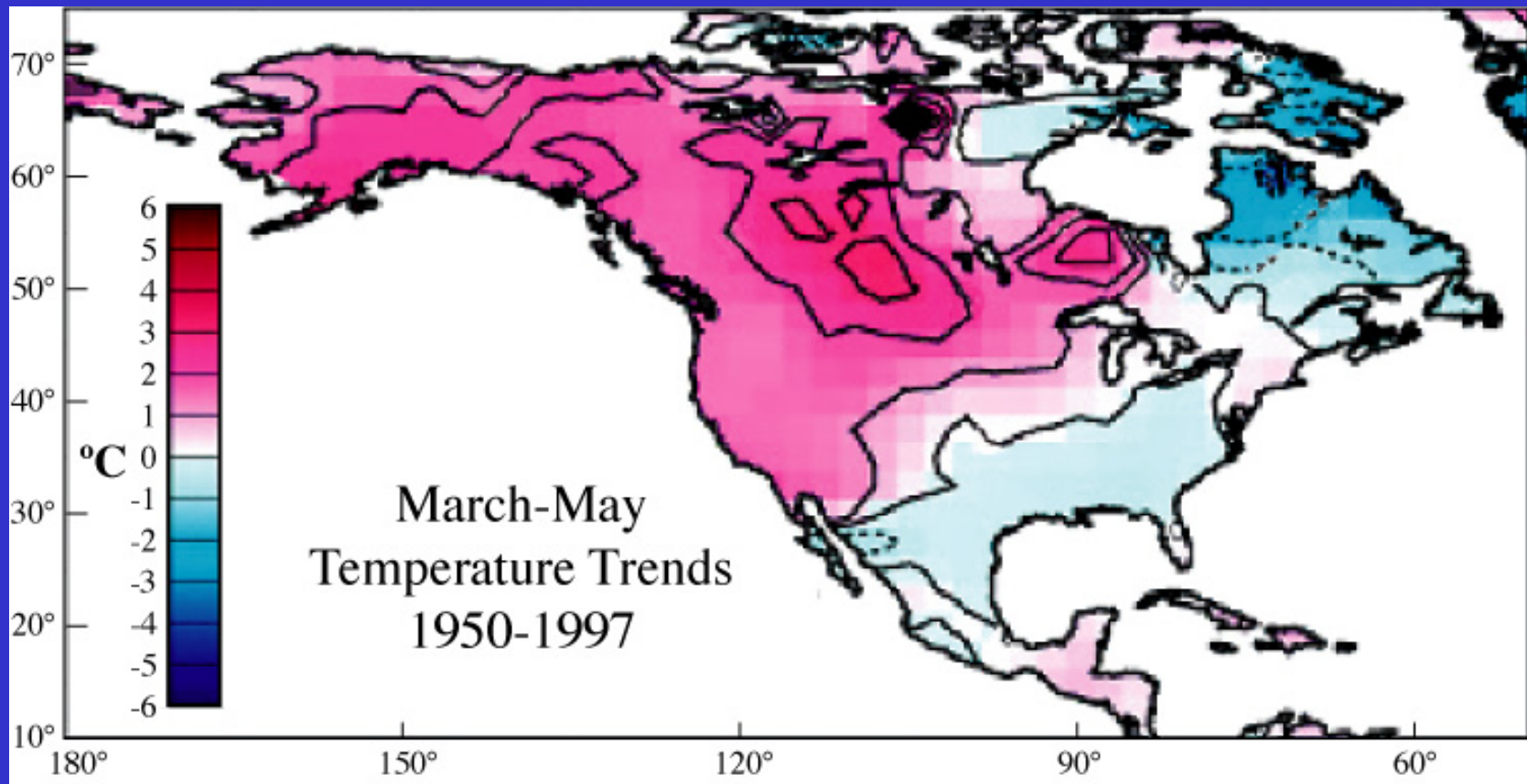


Trends in timing of spring snowmelt (1948-2000)

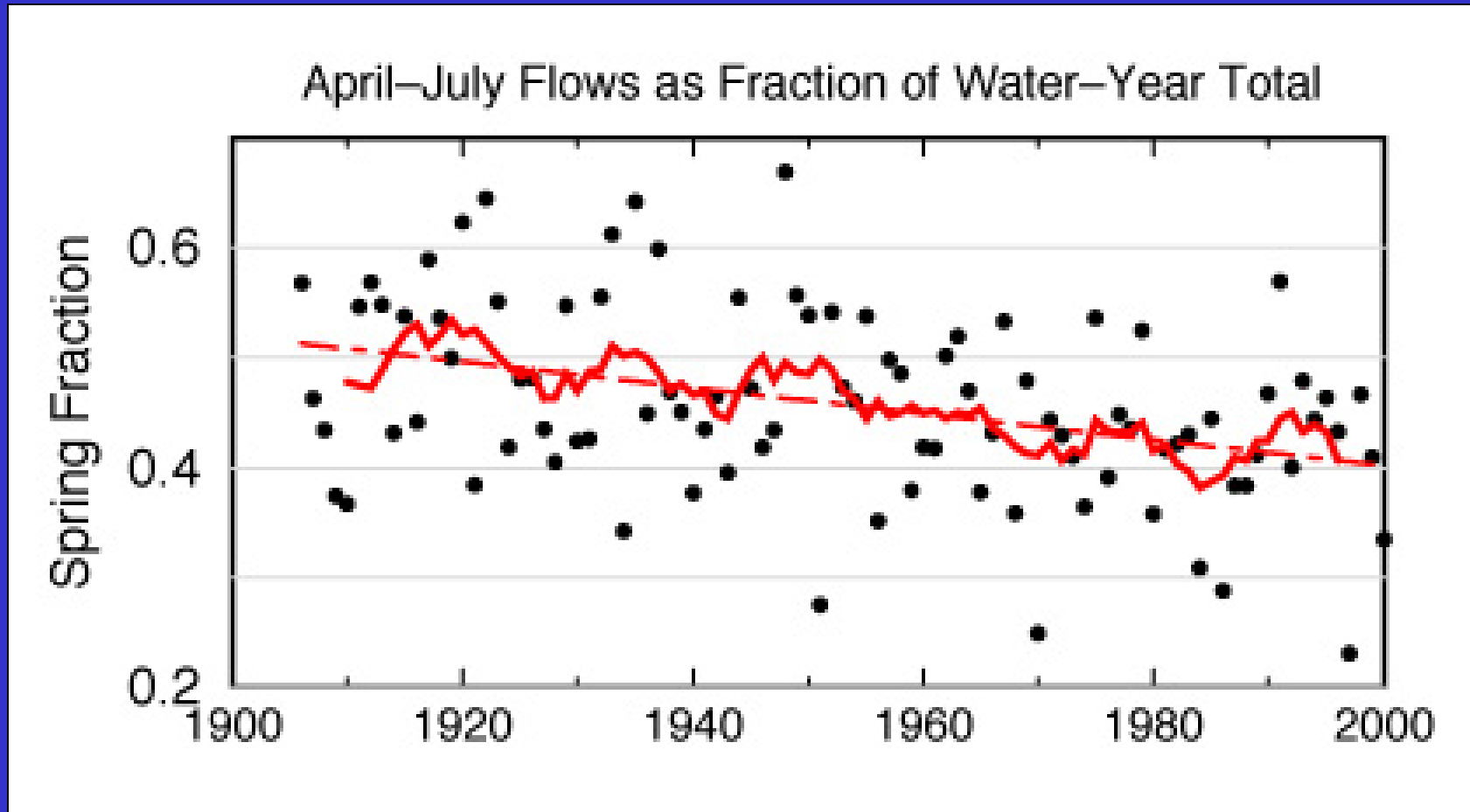


Courtesy of Mike Dettinger, Iris Stewart, Dan Cayan

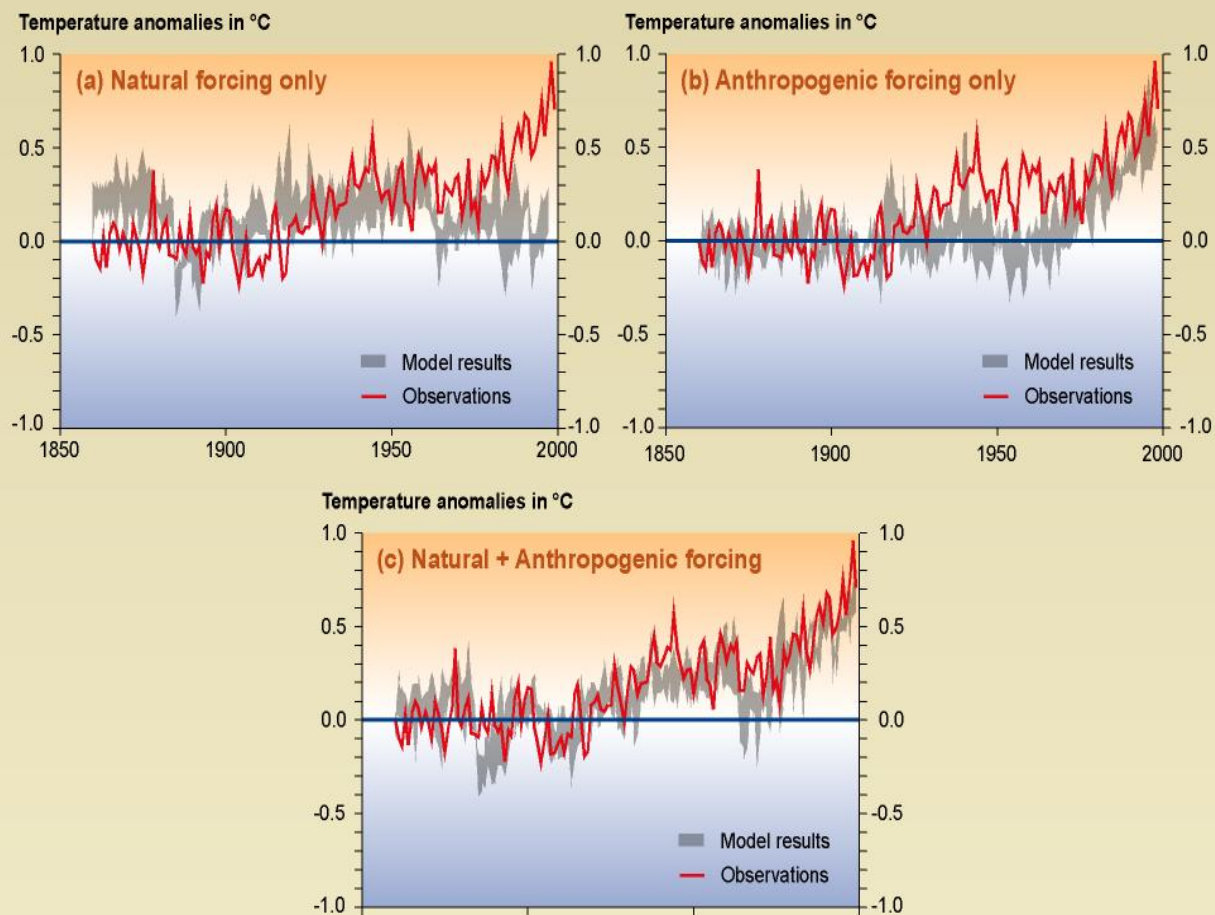
Not surprisingly, these timing and snowpack changes are attributable to **long-term winter-spring warming trends** across the West.



As a result of streamflow timing trends, the warm-season fraction of annual streamflow has declined.



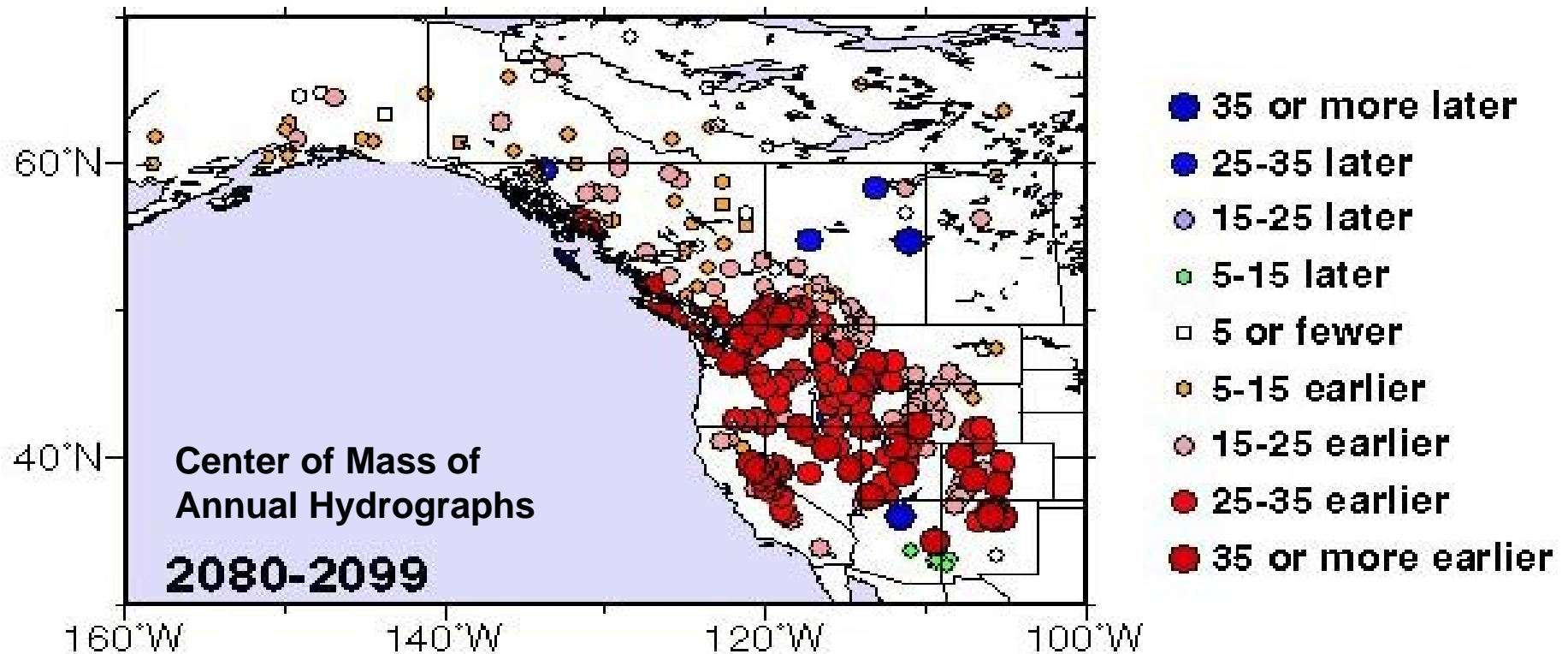
Comparison between modeled and observations of temperature rise since the year 1860



SYR - FIGURE 2-4

Trends toward earlier snowmelt runoff are projected to continue throughout the West.

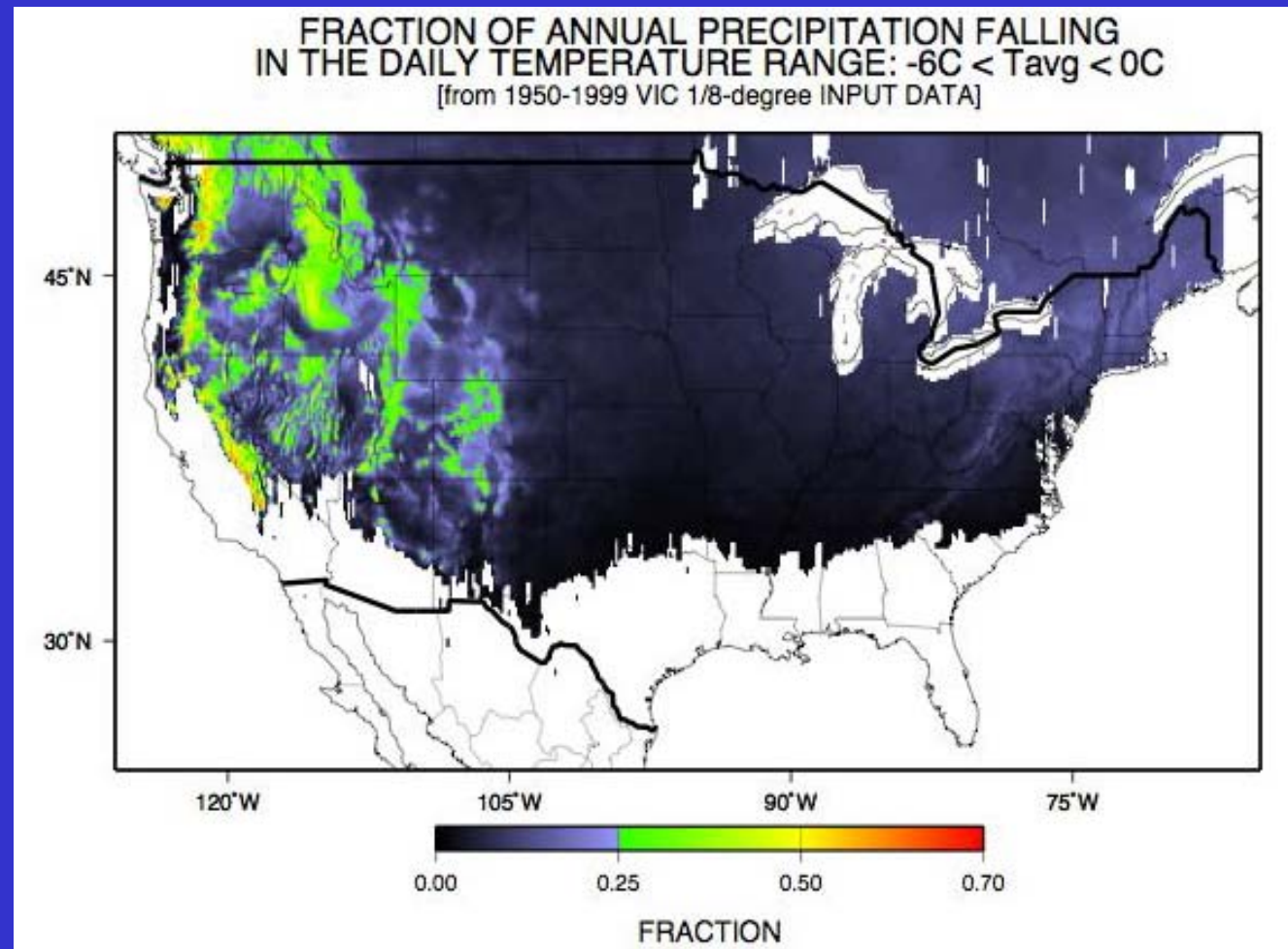
Projected streamflow timings, 2080-99 vs 1951-80



Stewart et al., 2004

Estimating Influences of Warming on SNOW vs RAIN

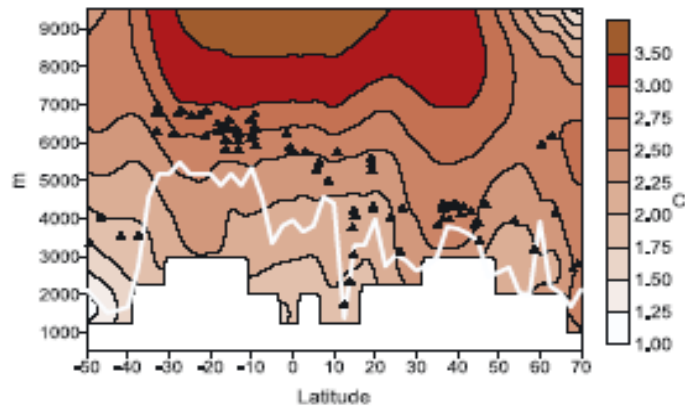
- Widespread shift from snow to rain
- The West is by far the most vulnerable
- Snow to rain transitions of over 25% annual precip would be common



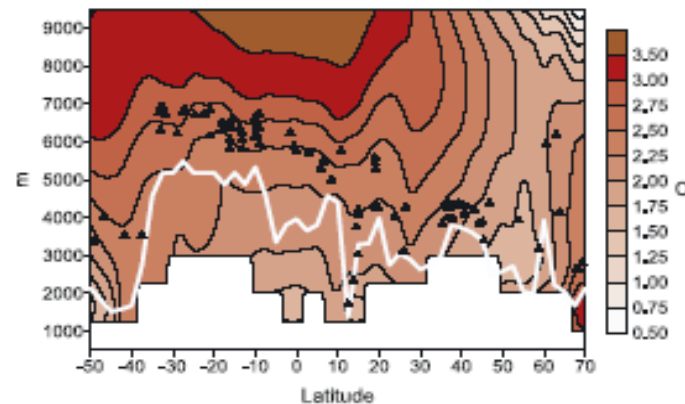
*Derived from UW's
VIC model daily inputs,
1950-1999*

Temperature Change At High Elevations

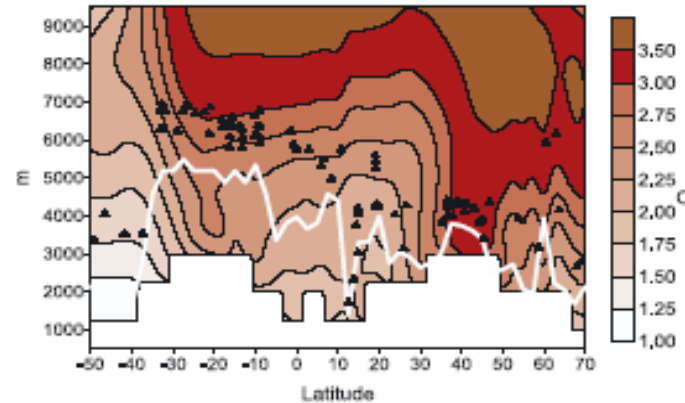
Projected Change-
Mean Annual Temp



Projected Change-
Dec-Feb Mean Temp



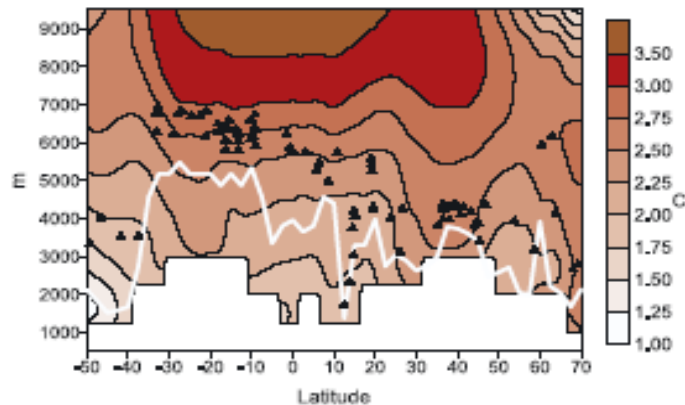
Projected Change-
June-Aug Mean Temp



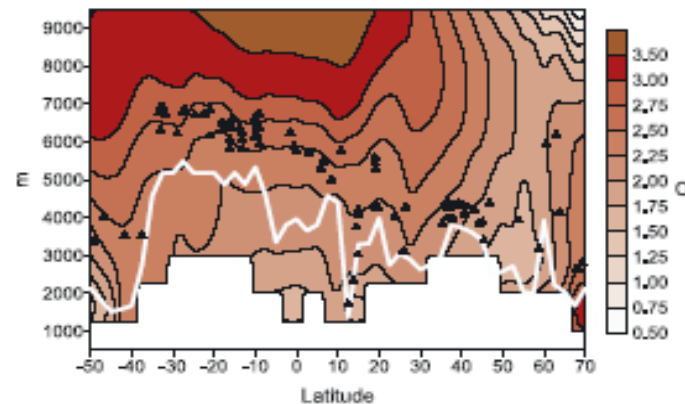
Bradley et al. 2004

Temperature Change At High Elevations

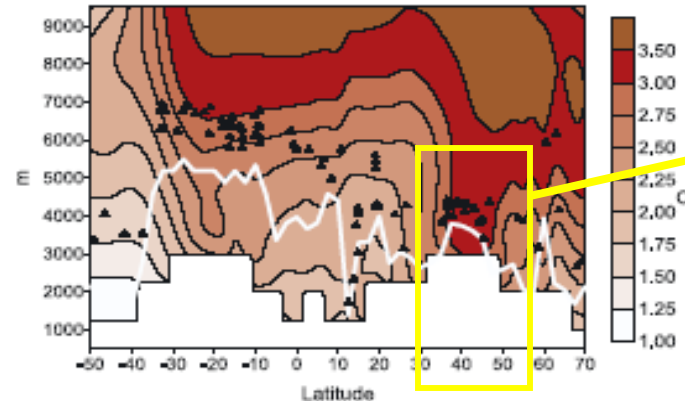
Projected Change-
Mean Annual Temp



Projected Change-
Dec-Feb Mean Temp



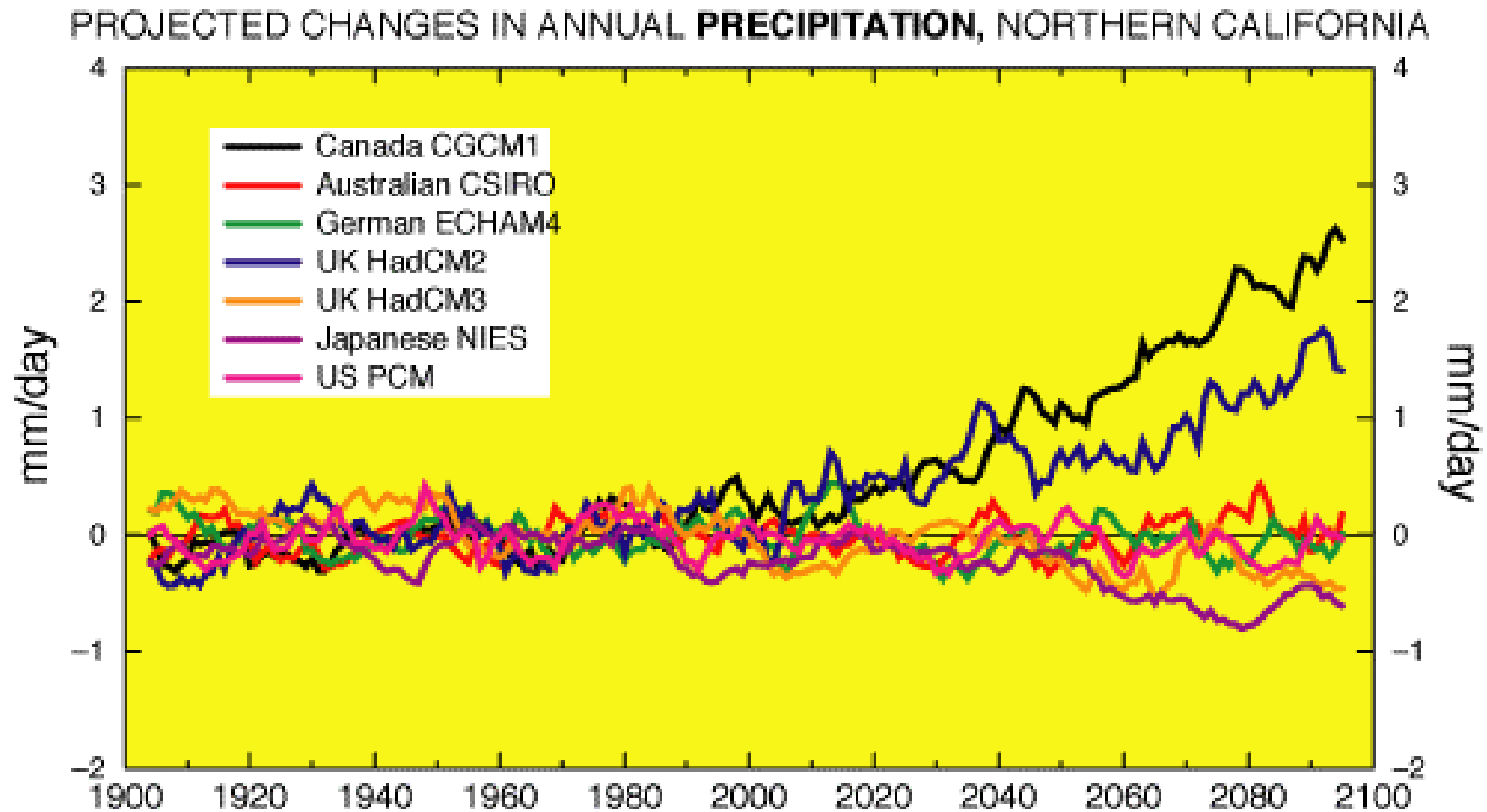
Projected Change-
June-Aug Mean Temp



Greatest change projected
at high elevations in NH
mid-latitudes

But what about precipitation?

Overall, climate models provide no consensus regarding the future of precipitation in the West.

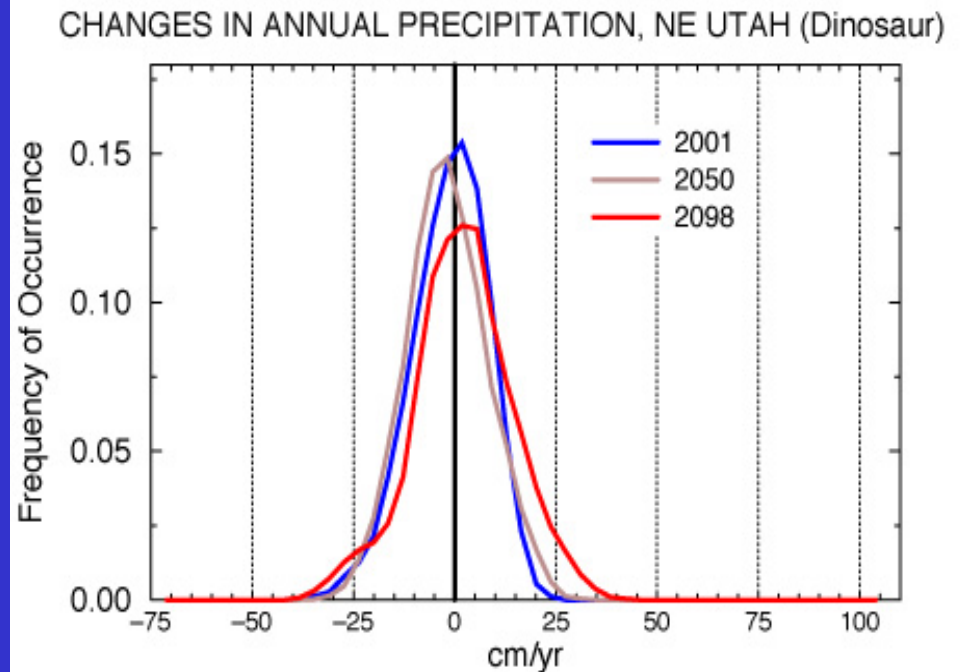
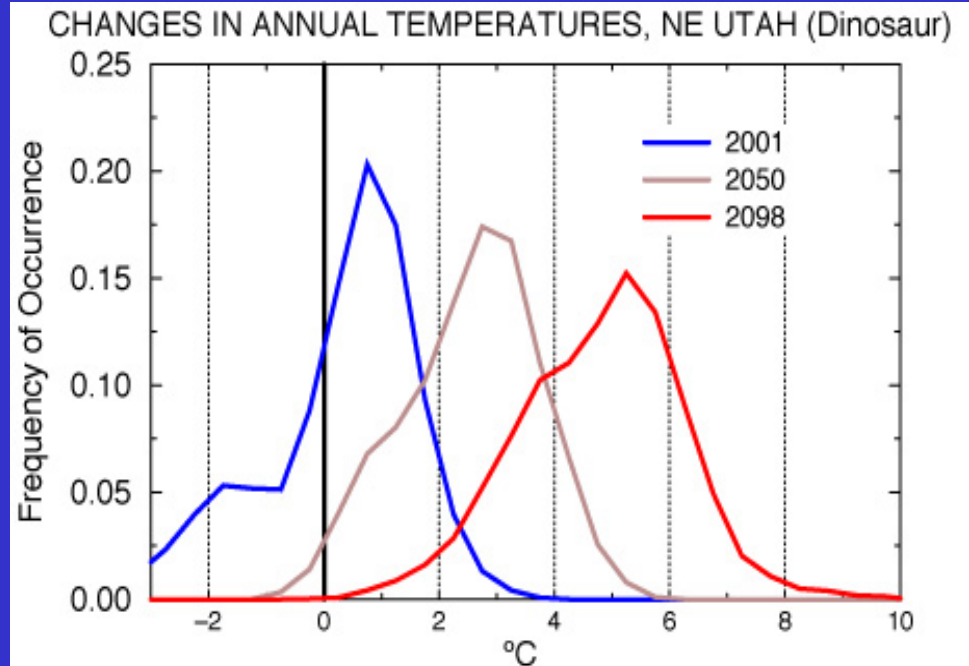


WHAT ARE CURRENT MODELS PROJECTING FOR THE WEST?

Warming by +2 to +7°C,
more at higher elevations

Uncertain precip. changes,
probably not significantly
outside range of nat. var.

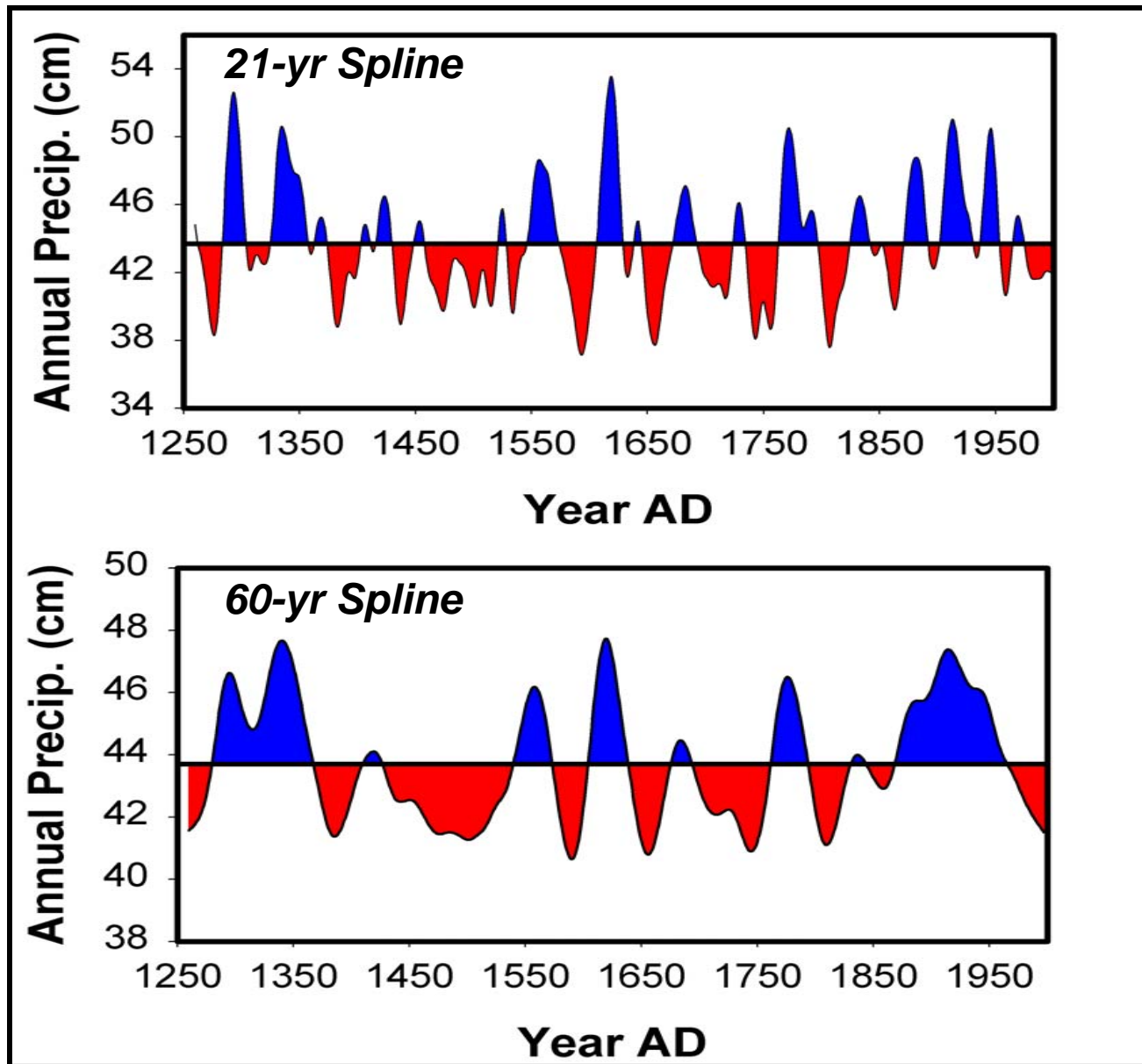
Reduced snowpack, earlier
snowmelt, earlier snowmelt
discharge, even if only
the temperature changes



Potential Impacts of Switch from Snow to Rain? Melt Timing?

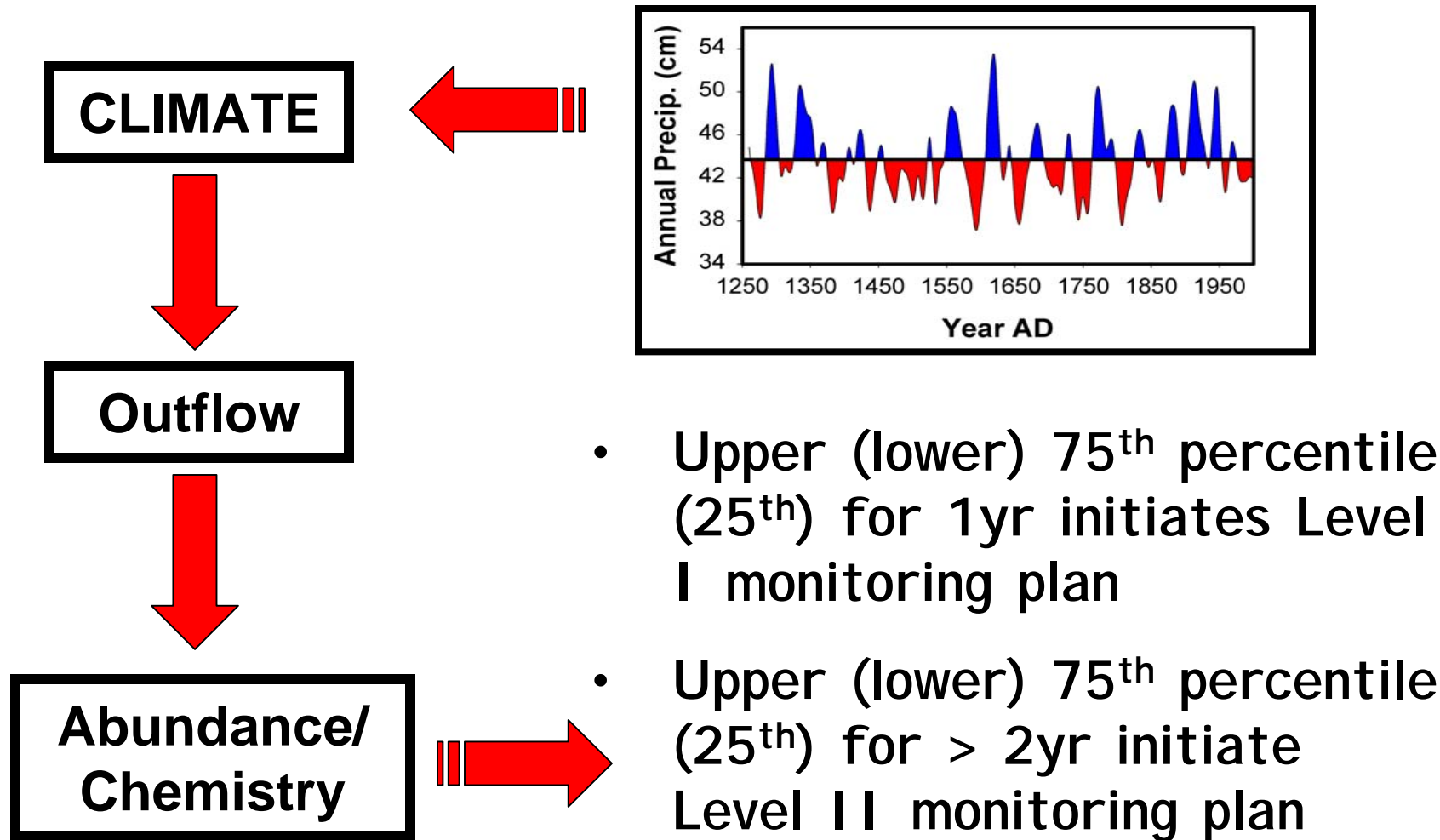
- Group exercise: Five key impacts for natural areas management
- Info needed to...
 - Monitor
 - Predict
- Sources of information... (Kelly Redmond and Connie Woodhouse)

Greater Yellowstone Climate

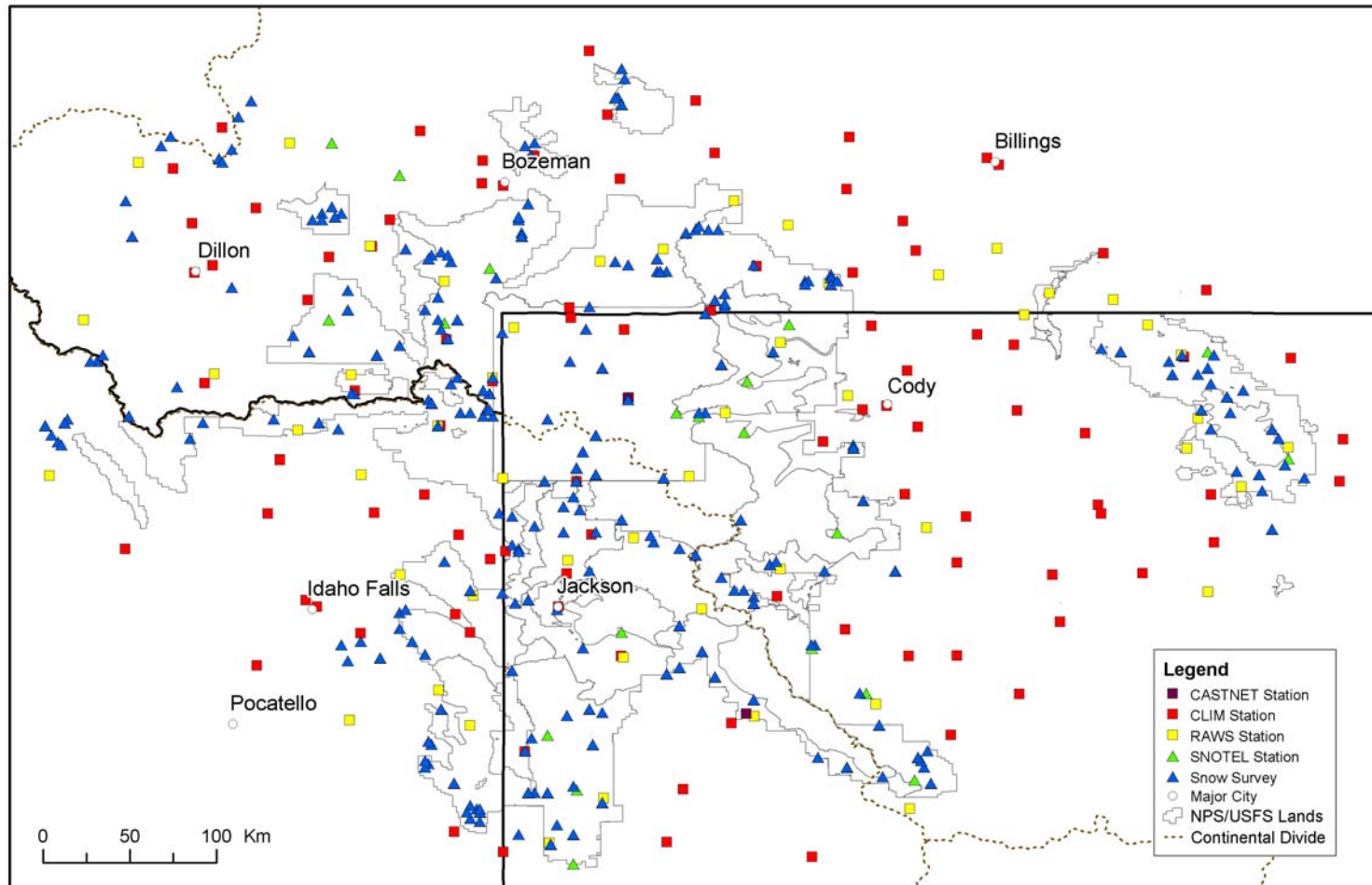


Gray, Graumlich and Pisaric (in prep)

Vital Signs Monitoring: Seeps and Springs



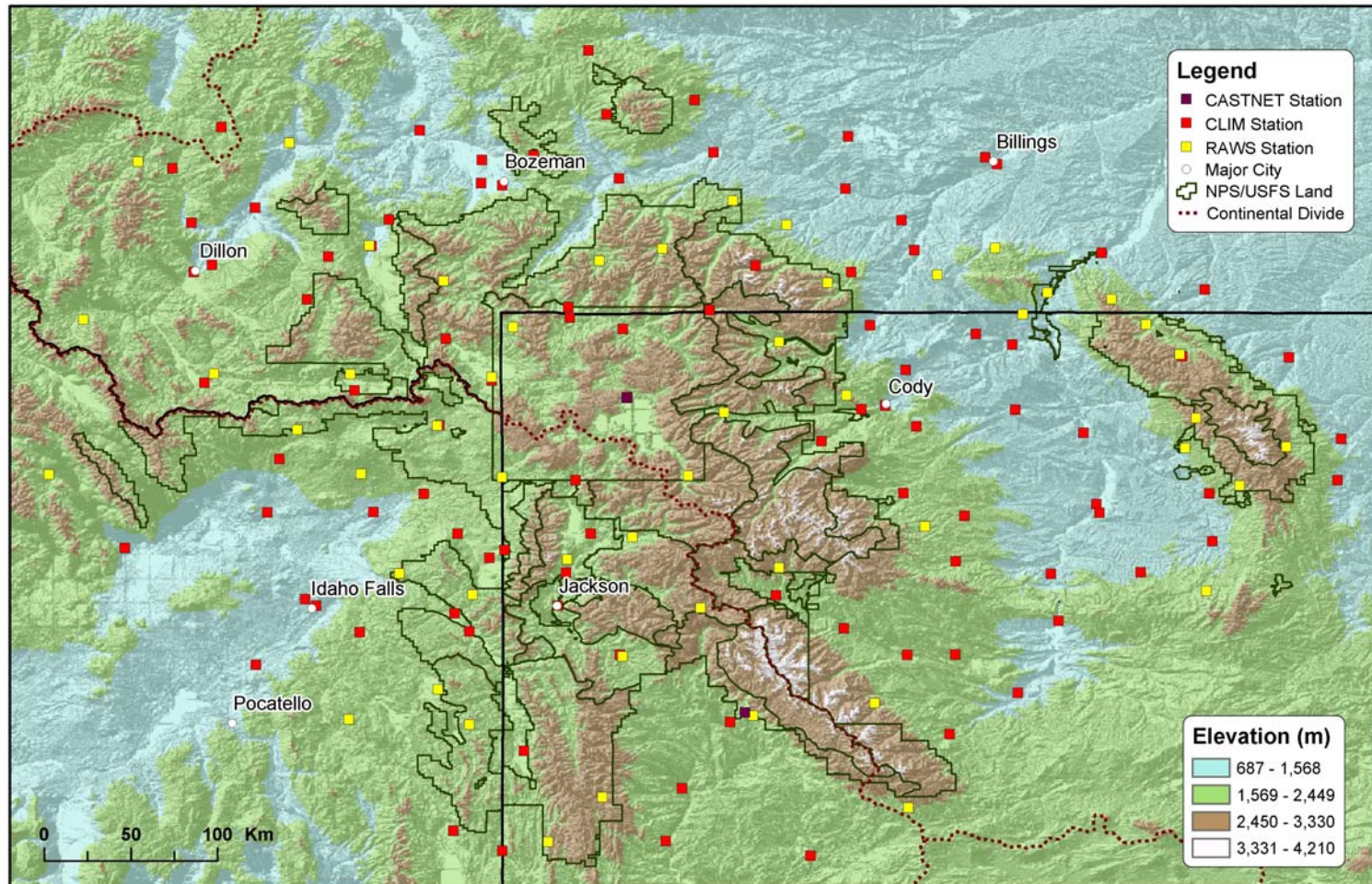
Climate Station Network of the Greater Yellowstone - Bighorn Canyon Area



Data Sources: Natural Resources Information System - Montana; University of Idaho Gap Analysis Program; University of Wyoming GISc Online Database; USGS National Elevation Dataset; the National Atlas Online Database

Meteorologic Climate Stations of the Greater Yellowstone - Bighorn Canyon Area

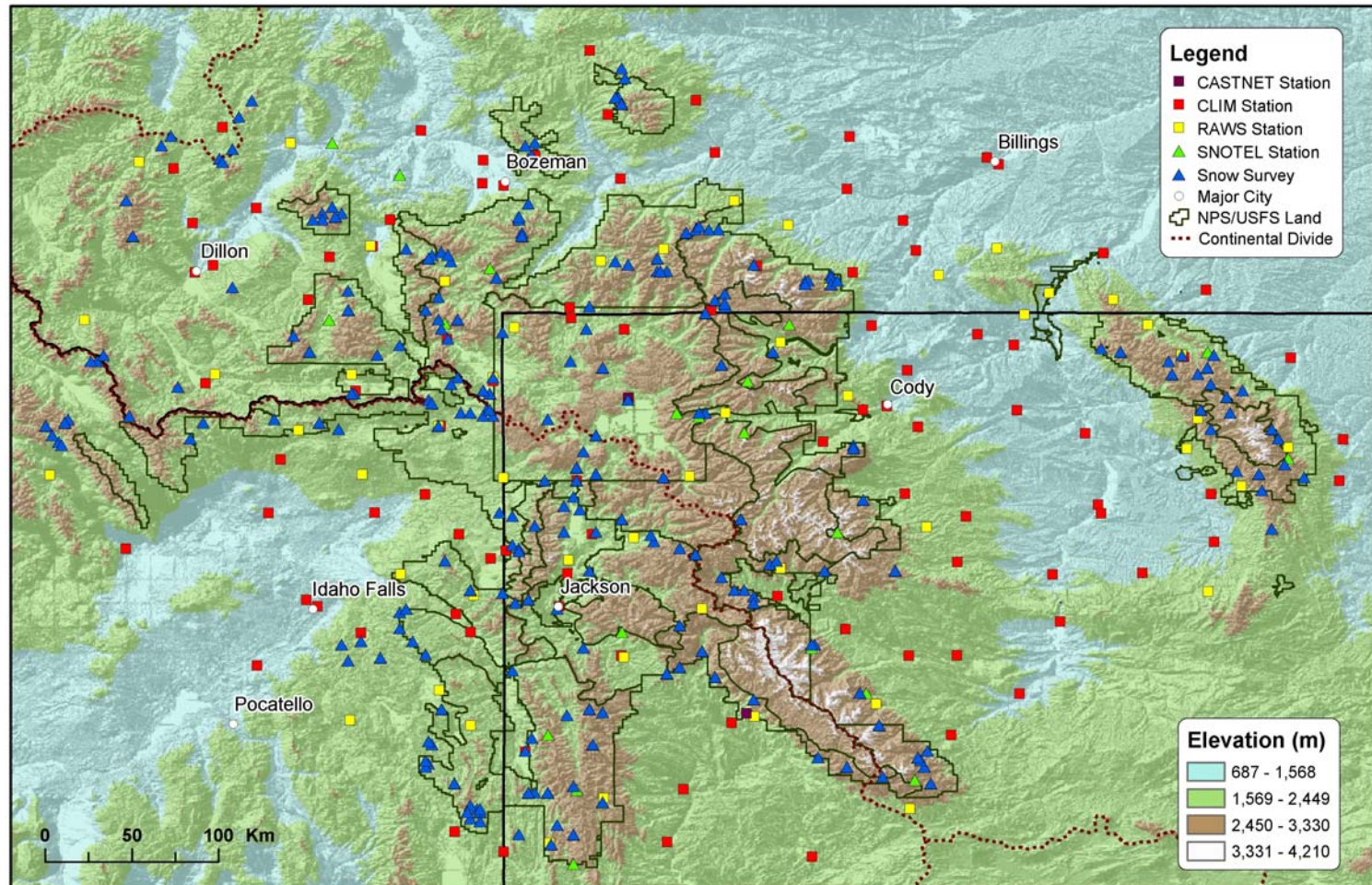
by Regional Equal Interval Elevation Ranges



Data Sources: Natural Resources Information System - Montana; University of Idaho Gap Analysis Program; University of Wyoming GISc Online Database; USGS National Elevation Dataset; the National Atlas Online Database

Climate Station Network of the Greater Yellowstone - Bighorn Canyon Area

by Regional Equal Interval Elevation Ranges



Data Sources: Natural Resources Information System - Montana; University of Idaho Gap Analysis Program; University of Wyoming GISc Online Database; USGS National Elevation Dataset; the National Atlas Online Database